2013 Annual Summary of Water Quality Observations in Select Streams of Chesterfield County

Powhite Creek south of W. Pinetta Drive in Bon Air, Virginia, May 2013

Chesterfield County
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Executive Summary

Ten stream sites were investigated during the year to monitor the general state of water quality throughout the county. These sites were monitored on a monthly basis.

A suite of instream parameters including dissolved oxygen, pH, conductivity, total dissolved solids, temperature and flow were measured at each site. Each month, samples were obtained and analyzed in the Water Quality Laboratory for ammonia and nitrate+nitrite nitrogen, phosphate phosphorus and turbidity. *E. coli* colony formation was measured on a bi-monthly basis. Fluoride and potassium concentrations were tested on a quarterly basis. Water quality observations were compiled and subjected to a set of calculations. These calculations categorized the streams' overall chemical health in one of three assessment categories: low, moderate and high water quality.

The majority (9) of the streams investigated during 2013 possessed moderate or high chemical water quality with low water quality observed at the one remaining site. As in previous years, impacts to the streams were attributed to frequent low pH, elevated nutrient concentrations and increased turbidity measurements. All annual medians of physical parameters were within acceptable ranges during 2013 with the exception of pH at Winterpock Creek WQ-71 and Tributary to Timsbury Creek WQ-79, where pH values were below the state water quality standard. *E. coli* counts indicated that concentrations do fluctuate with season and all median values met the state standard. Observations of fluoride and potassium indicated levels similar to those expected in groundwater.

Overall, ammonia nitrogen median concentrations were at acceptable levels during 2013 with three streams' annual median values greater than 0.04 mg/L as N. Annual median nitrate+nitrite nitrogen concentrations were generally elevated with eight of the ten monitored sites having annual median concentrations greater than 0.10 mg/L as N. Annual median concentrations of phosphate phosphorus were elevated in eight of the ten streams monitored during 2013 with concentrations greater than or equal to 0.02 mg/L as P. Turbidity measurements indicated generally clear waters throughout the county.

Annual rainfall for the county was approximately 48.8 inches; 4 inches above normal (average rainfall = 44 inches/year) for this area. Half of the sampling sites exhibited measureable flow throughout the year and the remaining half of the streams sites, experienced at least one instance of low flow (<0.01 m/s) conditions during 2013. All of the low flow events occurred during the fall months. Despite the low flow readings, none of the streams appeared dry during 2013.

Four of the ten monitored sites are currently recorded on Virginia's impaired waters list. Three of the four stream sites (Powhite Creek WQ-70, Winterpock Creek WQ-71 and Powhite Creek WQ-75) are impaired for not supporting aquatic life. Both Powhite Creek sites (WQ-70 and WQ-75) are also impaired for recreational contact. Tributary to Falling Creek WQ-76 is impaired for recreational contact only. The three watersheds identified as having impairments are each listed in a different impairment category. Strategies for bringing these streams into compliance with state standards will be developed by the Virginia Department of Environmental Quality.

Introduction

This report presents the physical and chemical water quality data collected by Chesterfield County's Water Quality Section for the period of January through December of 2013. This report is a major monitoring component of the Watershed Assessment and Stream Protection Program (WASP) portion of Chesterfield County's VPDES Permit VA0088609. For this program element, ten stream sites were investigated during the year to monitor the general state of water quality throughout the county and to augment the database used for trending and comparison of physical and chemical parameters. These sites were monitored on a monthly basis. Nine of sites monitored in 2013 have multi-year data. During 2013, nine sites assessed in 2012 continued to be monitored and one site (Tributary to Swift Creek WQ-72) was rotated off the schedule and replaced with a previously established site (Turkey Creek, WQ-27).

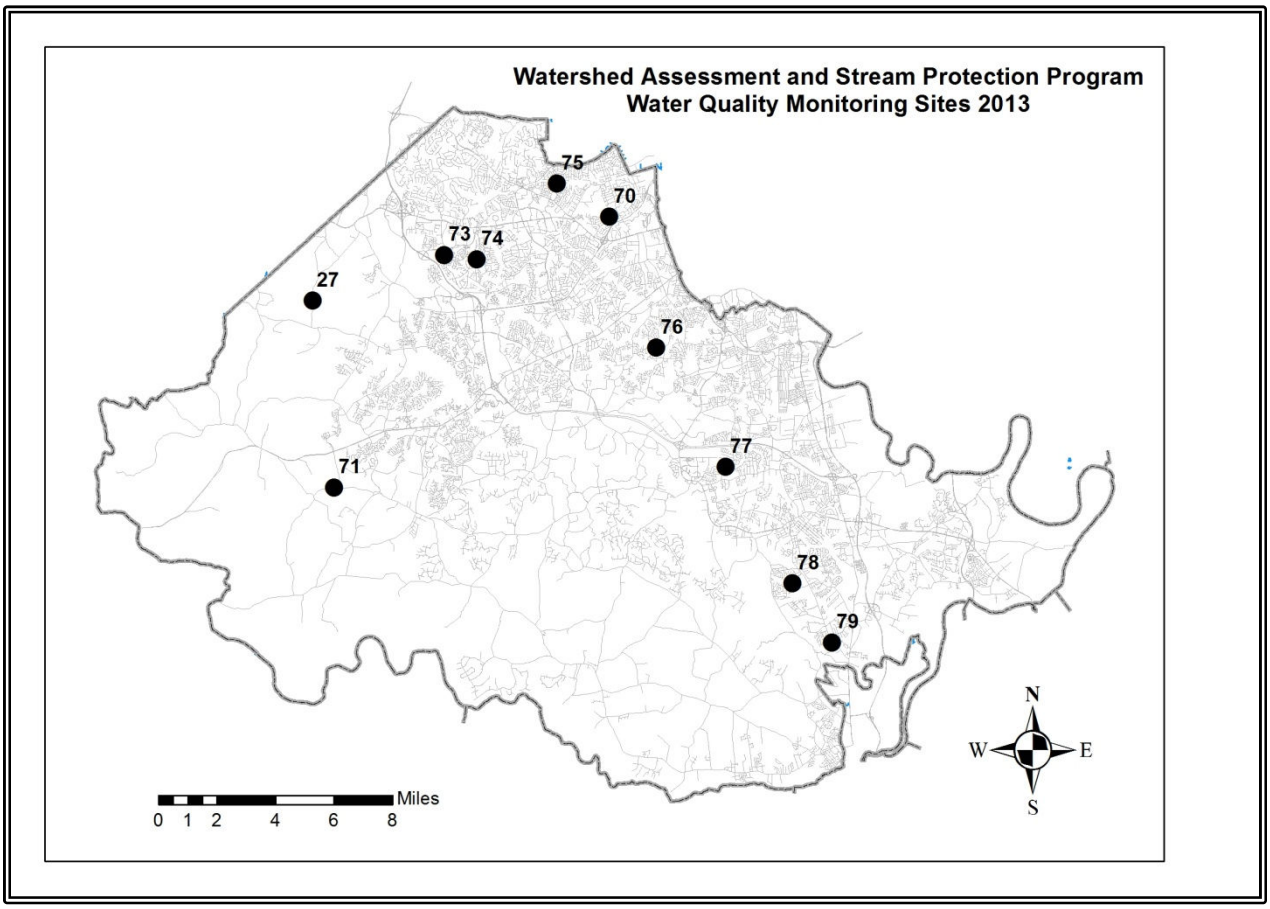

Figure 1. Water Quality Monitoring Sites for 2013

Stream sites were selected after a review of previous sites and watersheds assessed using maps produced from the county's Geographic Information System. Streams were selected to represent a variety of sizes and watersheds. Following the map analysis, field surveys were conducted to verify each site location's accessibility and feasibility. A list of stream sites was finalized and assigned a specific reference identifier consisting of the prefix "WQ" (*i.e.* water quality) followed by a sequentially increasing number (01 – 79) to differentiate them from other WASP

monitoring sites. Monitoring in 2013 continued to follow the methods and protocols used in previous years.

Methods

Stream sites were sampled monthly over a range of baseflow conditions. Physical parameters were measured *in situ* with a Hydrolab® Minisonde water quality multiprobe in conjunction with a Surveyor 4a data logger system. The Hydrolab® Minisonde multiprobe was calibrated using commercially prepared buffer solutions prior to deployment to the field. These calibrations were rechecked upon return from the field to ensure the probe maintained calibration during use. Parameters measured in the field included water temperature, pH, dissolved oxygen, conductivity, total dissolved solids and depth. A semi-quantitative measure of flow was also obtained onsite by recording the time it took for a float to travel one meter. Ambient air temperature was additionally noted.

Water quality samples were collected in 237 ml low-density polyethylene containers. Samples were obtained from the bank of each site just below the surface of the water by hand or a long handled sampling pole and placed in a cooler on ice for transfer to the water quality laboratory. Upon returning to the laboratory, sample information was recorded and each sample assigned a unique lab identification number in an EXCEL spreadsheet. Samples were then stored at $\leq 4^{o}$C in the laboratory refrigerator until time of analysis. Care was taken to adhere to analytical holding times for specific analytes.

In the laboratory, water samples were analyzed monthly for four parameters: ammonia nitrogen, nitrate+nitrite nitrogen, phosphate phosphorus and turbidity. Fluoride and potassium concentrations were analyzed on a quarterly basis. The fluoride and potassium analytes were added in 2010 to establish their naturally occurring background levels within county waters to aid in future stormwater pollution prevention efforts. Both fluoride and potassium occur naturally in ground and surface waters but they can also be indicators of pollution. Elevated fluoride is a potential indicator of drinking/tap water intrusion and elevated potassium levels are an indicator of industrial and commercial wastes. Both can be a potential indicator of sanitary wastewater but bacterial counts are the best indicator of sewage. On a bi-monthly schedule, the samples were tested for *Escherichia coli* (*E. coli*). In 2011, *E. coli* was added to the testing parameters because fecal bacteria contamination of surface waters in Virginia has been identified by the Virginia Department of Environmental Quality (VADEQ) as a problem in Virginia. Many streams in the state, including in Chesterfield County, have been listed by the VADEQ as impaired as a result of bacterial contamination. With the addition of *E. coli* testing, a baseline for colony concentrations in the streams may be developed and streams with potential fecal contamination may be identified. Nutrient and chemical analyses were conducted using a Palintest® 8000 series photometer. Palintest® environmental testing company methods specific to the photometer were used and generally reflected those outlined in *Standard Methods*. Turbidity was measured using a Cole-Parmer nephelometric turbidimeter following procedures outlined in *Standard Methods*. *E. coli* was measured using the Coliscan® Easygel® method.

Quality Assurance and Quality Control

For each parameter analyzed in the laboratory, Method Detection Limits (MDLs) were calculated (study conducted November 2011) following the procedure outlined in Section 1030E of *Standard Methods*. Laboratory reporting limits were determined from these MDLs. On the day of sample analysis, instrument calibration was verified using a set of photometer primary standards obtained from Palintest®. To insure analytical precision and accuracy, known quality control samples for ammonia nitrogen, nitrate+nitrite nitrogen and phosphate phosphorus were analyzed. Values obtained were compared to the manufacturer's acceptable recovery limits. Out of tolerance values were noted and evaluated for potential causes of error. Due to lack of availability, known concentrations of fluoride, potassium and *E. coli* were not analyzed. Instrument calibration for the turbidimeter was checked and verified prior to analysis using secondary standards applicable to the range of turbidity expected.

Sample replicates were analyzed every ten samples for each parameter and relative percent differences were calculated. Analytical blanks were used in order to detect any potential contamination that may have occurred during sampling or sample preparation. Manufacturer's recommendations for preventive maintenance were followed for all instruments.

A summary of the tests, methods and reporting limits as well as applicable water quality standards for the analyses are outlined in Table 1.

Comparative Index of Chemical Water Quality

The index of water quality developed and used for the 2002 - 2012 data to describe relative chemical water quality among the sites continued in 2013. Monthly water quality measurements were entered into an EXCEL spreadsheet and quality scores were assigned based upon values obtained from literature and a web based search of Virginia, Mid-Atlantic States and Regional EPA water quality standards. The measurement scores were summed and compared to an ideal score (*i.e.* the score if all measurements met the standards). Cumulative percentile plot analysis resulted in a set of three criteria based upon natural breaks in the data (generally the 25^{th} and 70^{th} percentile). These data sets were categorically identified respectively as "high," "moderate" and "low" quality. Annual median scores were calculated and used to characterize the overall chemical water quality for each site. It should be noted that the index should not be interpreted as a full measure of aquatic health as it only relates to the identified parameters relative to the 2013 data set. Other indices that incorporate benthic macroinvertebrate and instream habitat data may yield a different assessment and should not be compared to the results of this analysis. A copy of the EXCEL spreadsheet with the calculations will be made available for review upon request.

Table 1. Parameters and Analytical Methods

Parameter	Analytical Method	Reporting Limit	Water Quality Standard	**Reference**
Dissolved Oxygen	Probe: Hydrolab® Minisonde	0.1 mg/L*	≥ 4.0 mg/L	VADEQ
pH	Probe: Hydrolab® Minisonde	0.2 units*	6.0 – 9.0 units	VADEQ
Conductivity	Probe: Hydrolab® Minisonde	1.0 µS/cm*	≤ 500 µS/cm	None
Total Dissolved Solids	Probe: Hydrolab® Minisonde	0.1 mg/L*	≤ 500 mg/L	PA State Standard
Temperature	Probe: Hydrolab® Minisonde	0.1 ^{o}C*	≤ 32 ^{o}C	VADEQ
Fluoride	Palintest®: Photometric	0.15 mg/L	0.13 mg/L Groundwater	Brown & Caraco, 2004
Potassium	Palintest®: Na^{+} Tetraphyenyl	0.3 mg/L	3.1 mg/L Groundwater	Brown & Caraco, 2004
Ammonia Nitrogen	Palintest®: Phenate	0.02 mg/L	0.04 mg/L Forested Area	Schueler, 1997b
Nitrate/Nitrite Nitrogen	Palintest®: Nitratest	0.02 mg/L	0.10 mg/L Nitrate+Nitrite	USEPA, 2000
Phosphate Phosphorus	Palintest®: Phosphate LR	0.02 mg/L	0.01 mg/L Forested Area	Caraco, 2001
Turbidity	Standard Method 2130B Nephelometric	1.0 NTUs	4 NTUs	USEPA, 2000
Escherichia coli	Coliscan® Easygel®	20CFU/100mL*	235CFU/100mL	VADEQ
Flow	USGS: Float	0.01 m/s	None	None

**When a method detection limit was not applicable for a parameter, it was replaced by an estimation of accuracy based on manufacturer's specifications.*

Site Descriptions and Summaries

The following pages describe each site and contain a summary of the observations made during the course of the year. All photos depict upstream views unless otherwise noted. Left and right banks are referenced from the perspective looking upstream. Latitude and longitude are reported in decimal degrees. Field data sheets and associated notes are located in Appendix A following this report.

Site Number WQ-27

Stream: Turkey Creek

Site: Immediately Downstream of the Mount Hermon Road Bridge Crossing, Moseley, Virginia

Latitude: 37.46677
Longitude: 77.74271

Watershed: Upper Swift Creek

Stream Order: 3

Land use: Pasture, rural residential and forest

Gradient: Low

View is downstream

Field and Laboratory Observations:

Date	Dissolved Oxygen (mg/L)	pH (units)	Conductivity (microS/cm)	Total Dissolved Solids (mg/L)	Temperature (Degrees C)	Ammonia (mg/L as N)	Nitrate+Nitrite (mg/L as N)	Phosphate (mg/L as P)	Turbidity (NTUs)	*E. Coli* CFU/100mL	Flow m/s	Index Score %Comparision
01/22/13	13.3	4.1	54	34.4	2.6	0.02	0.08	0.02	5.5	*	0.54	80.0
02/12/13	12.4	6.0	59	38.0	6.4	<0.02	0.04	0.02	4.2	20	0.15	93.8
03/20/13	12.2	6.4	45	28.2	5.3	0.39	0.03	0.02	4.4	*	0.17	73.3
04/22/13	10.8	6.3	44	28.1	9.5	<0.02	0.06	<0.02	4.1	20	0.22	100.0
05/21/13	7.9	6.4	55	35.0	18.2	<0.02	0.03	0.02	4.0	*	0.15	93.3
06/17/13	6.9	6.4	73	46.7	20.3	0.05	0.06	0.04	5.5	120	0.03	81.3
07/15/13	8.1	6.1	32	20.5	21.8	0.02	0.05	0.05	5.7	*	0.15	86.7
08/12/13	6.2	6.6	76	48.5	23.1	0.02	0.07	0.05	4.2	40	<0.01	93.8
09/18/13	6.6	6.7	98	62.6	14.3	0.02	0.05	0.07	3.9	*	<0.01	93.3
10/22/13	5.1	6.7	100	63.6	11.0	<0.02	0.03	0.03	2.8	<20	<0.01	93.8
11/13/13	5.6	6.4	97	62.1	5.0	<0.02	0.04	0.04	2.3	*	<0.01	93.3
12/16/13	12.1	6.5	49	31.6	4.4	<0.02	0.07	0.06	5.9	<20	0.24	87.5
Minimum	5.1	4.1	32	20.5	2.6	<0.02	0.03	<0.02	2.3	<20	<0.01	73.3
Median	**8.0**	**6.4**	**57**	**36.5**	**10.2**	**0.02**	**0.05**	**0.04**	**4.2**	**20**	**0.15**	**93.3**
Maximum	13.3	6.7	100	63.6	23.1	0.39	0.08	0.07	5.9	120	0.54	100.0
2004 Median	**8.1**	**6.3**	**50**	**31.7**	**13.3**	**<0.02**	**0.04**	**0.02**	**<5.0**	*	**0.06**	**93.3**

This monthly sampling site on Turkey Creek was established in January of 2004 and revisited in 2013. Turkey Creek is a perennial tributary of Swift Creek located in the Triassic Basin region of Chesterfield County. The stream's substrate is primarily comprised of sand and gravel with some silt and cobbles present. Flow at this site was seen throughout most of the year with four observation of low flow. The water appeared clear most of the year with one observation of a stained coloration. The banks were well vegetated and were slightly eroded. The riparian area consisted of well forested land dominated by trees and shrubs. Upstream of the sight is a large active agricultural field that appears to be used for hay growth and horse pastures. Periphyton was commonly observed during site visits. Other biota observed included algae and water striders.

Samples were obtained from the left bank at a median depth of 0.07 meters. The annual median index score (93.3%) indicated high chemical water quality. This site scored the highest among all sites and was the only site observed to have high chemical water quality in 2013. All annual medians of the chemical parameters were within acceptable ranges. However, during January, pH (4.1 units) violated state water quality standards. The annual median turbidity (4.2 NTUs), was the lowest observed among all sites in 2013. Overall, there was very little nitrogen enrichment observed at this site. The annual median ammonia nitrogen concentration was 0.02 mg/L as N and the annual median nitrate+nitrite concentration (0.05 mg/L as N) was the lowest observed among all sites. The phosphate phosphorus annual median was 0.04 mg/L as P. The annual median *E. coli* concentration was 20 CFUs/100mL and there were no instances exceeding the state bacterial water quality standard. The annual median fluoride concentration was 0.41 mg/L, indicating levels similar to groundwater. The annual potassium median concentration (2.2 mg/L) indicated levels similar to ground water.

Site Number WQ-70

Stream: Powhite Creek

Site: Approximately 100 meters downstream of W. Pinetta Drive, Bon Air, Virginia

Latitude: 37.50694
Longitude: 77.55749

Watershed: James River

Stream Order: 2

Land use: Residential and forest

Gradient: Low

Field and Laboratory Observations:

Date	Dissolved Oxygen (mg/L)	pH (units)	Conductivity (microS/cm)	Total Dissolved Solids (mg/L)	Temperature (Degrees C)	Ammonia (mg/L as N)	Nitrate+Nitrite (mg/L as N)	Phosphate (mg/L as P)	Turbidity (NTUs)	*E. Coli* CFU/100mL	Flow m/s	Index Score %Comparison
01/22/13	12.0	6.3	67	43.2	4.1	0.05	0.47	0.03	6.5	*	0.34	60.0
02/12/13	11.6	6.6	133	85.2	9.2	<0.02	0.24	<0.02	4.3	<20	0.41	87.5
03/20/13	11.3	6.9	123	78.9	7.8	0.07	0.33	0.10	6.9	*	0.42	66.7
04/22/13	8.5	6.9	130	83.2	13.3	0.11	0.09	<0.02	4.7	<20	0.43	93.8
05/21/13	5.6	6.5	130	83.4	21.6	0.10	0.15	0.05	6.4	*	0.51	73.3
06/17/13	5.8	6.5	125	79.7	23.5	0.08	0.11	0.04	5.7	20	0.36	75.0
07/15/13	5.9	6.4	118	75.2	26.5	0.09	0.18	0.07	4.6	*	0.40	80.0
08/12/13	5.5	6.3	102	65.0	26.6	0.11	0.11	0.05	4.7	<20	0.25	81.3
09/18/13	7.1	6.6	115	73.5	16.6	0.02	0.07	0.05	5.2	*	0.05	86.7
10/22/13	7.6	6.8	119	75.9	13.5	0.03	0.10	0.05	4.1	<20	0.19	93.8
11/13/13	10.4	6.9	123	78.4	5.3	<0.02	0.05	0.05	5.2	*	0.19	86.7
12/16/13	10.7	7.1	98	62.8	4.8	0.51	0.42	0.03	8.5	<20	0.40	50.0
Minimum	5.5	6.3	67	43.2	4.1	<0.02	0.05	<0.02	4.1	<20	0.05	50.0
Median	8.1	6.6	121	77.2	13.4	0.08	0.14	0.05	5.2	<20	0.08	80.6
Maximum	12.0	7.1	133	85.2	26.6	0.51	0.47	0.10	8.5	20	0.51	93.8
2012 Median	7.0	6.5	116	74.4	17.9	0.06	0.12	0.06	6.0	40	0.32	75.0
2011 Median	6.9	6.5	121	78.0	15.0	0.06	0.17	0.05	5.7	90	0.31	75.0

This was the third consecutive year this site has been evaluated and is approximately two and a half miles downstream of the sampling site Tributary to Powhite Creek WQ-75. Powhite Creek is a perennial tributary of the James River located in the Piedmont region of Chesterfield County. The stream's substrate is composed of firm sand and gravel; samples were taken from a large sand bar where emergent aquatic plant vegetation grew during the warm seasons. The stream was observed to have strong flows throughout the year. The water appeared alternately stained (n=7) and clear (n=6) throughout the year. The banks appeared slightly eroded. The banks were well vegetated along the reach. The riparian buffer consisted of trees, shrubs and seasonal herbaceous growth. Periphyton was observed throughout the year. Algae, submergent and emergent plants, *Corbicula* shells and fish were observed at various times.

Samples were obtained from the right bank at a median depth of 0.15 meters. The annual median index score (80.6%) was slight improved from the two previous year and indicated moderate water quality. All annual medians of the chemical parameters were within acceptable ranges. There were no incidences of dissolved oxygen or pH violating state water quality standards. The annual median turbidity was 5.2 NTUs supporting observations of clear to stained water during the year. Both nitrogen annual medians increased in 2013. The annual median ammonia nitrogen concentration was 0.08 mg/L as N; the highest median observed among sites. The nitrate+nitrogen annual median was 0.14 mg/L as N. The phosphate phosphorus annual median was 0.05 mg/L as P; the highest observed among all sites. The *E. coli* median was <20 CFU/100mL. The median fluoride value was 0.15 mg/L and the potassium annual median was 2.2 mg/L both indicating levels similar to expected groundwater concentrations.

Site Number WQ-71

Stream: Winterpock Creek

Site: Approximately 20 meters upstream of Beach Road, Matoaca, Virginia

Latitude: 37.37402
Longitude: 77.73029

Watershed: Appomattox River

Stream Order: 2

Land use: Forested with some residential

Gradient: Low

Field and Laboratory Observations:

Date	Dissolved Oxygen (mg/L)	pH (units)	Conductivity (microS/cm)	Total Dissolved Solids (mg/L)	Temperature (Degrees C)	Ammonia (mg/L as N)	Nitrate+Nitrite (mg/L as N)	Phosphate (mg/L as P)	Turbidity (NTUs)	*E. Coli* CFU/100mL	Flow m/s	Index Score %Comparison
01/22/13	12.4	4.5	54	34.7	3.8	<0.02	0.07	0.04	4.4	*	0.23	86.7
02/12/13	11.7	4.2	60	37.9	6.8	<0.02	0.06	<0.02	3.8	<20	0.32	93.8
03/20/13	11.7	5.0	49	31.1	5.3	0.10	0.16	0.02	4.2	*	0.52	73.3
04/22/13	10.4	5.5	46	29.0	9.4	<0.02	0.05	<0.02	4.1	<20	0.18	93.8
05/21/13	8.4	5.6	50	32.2	17.2	<0.02	0.05	<0.02	5.8	*	0.29	86.7
06/17/13	7.3	5.6	43	27.4	19.4	<0.02	0.04	<0.02	7.2	20	0.36	87.5
07/15/13	7.9	5.3	36	22.8	21.2	0.02	0.08	0.02	5.0	*	0.42	80.0
08/12/13	7.1	5.9	40	25.6	22.4	0.02	0.03	0.05	6.4	20	0.30	81.3
09/18/13	2.8	5.4	48	30.7	13.0	<0.02	0.05	0.03	5.7	*	<0.01	73.3
10/22/13	1.3	5.2	82	52.3	12.0	<0.02	0.08	0.04	8.7	<20	<0.01	68.8
11/13/13	1.9	5.6	84	53.7	8.5	<0.02	0.05	0.03	3.4	*	<0.01	80.0
12/16/13	11.9	5.7	49	31.5	4.9	0.05	0.05	0.02	4.7	<20	0.37	81.3
Minimum	1.3	4.2	36	22.8	3.8	<0.02	0.03	<0.02	3.4	<20	<0.01	68.8
Median	8.1	5.4	49	31.3	10.7	<0.02	0.06	0.02	4.9	<20	0.30	81.3
Maximum	12.4	5.9	84	53.7	22.4	0.10	0.16	0.05	8.7	20	0.52	93.8
2012 Median	8.5	5.6	45	28.5	11.3	<0.02	0.02	0.03	3.8	20	0.08	87.5

This was the second consecutive year this sampling site has been evaluated. Winterpock Creek is a perennial tributary of the Appomattox River located in the Triassic region of Chesterfield County. The substrate is composed of firm sand and gravel. Flow was observed throughout most of the year with three observations of low flow in autumn. The water appeared either clear (n=7) or stained (n=5) during the year. The stream banks were moderately to heavily eroded, with evidence of erosional scaring along the banks of the reach. The riparian buffer was well forested with trees and shrubs and some herbaceous plants. Periphyton was observed throughout the year along with algae, iron bacteria and bacterial sheens.

Samples were obtained from the left bank at a median depth of 0.04 meters. The annual median index score (81.3%) indicated moderate chemical water quality; a decrease from the observed high quality indicated in 2012. All annual medians of chemical parameters were within acceptable ranges except for pH. The annual pH median (5.4 units) violated the state water quality standard and was the lowest annual median pH among all sites. Dissolved oxygen (annual median 8.1) violated the state water quality standard three times during the year. The dissolved oxygen finding is not unusual as this stream is listed as a naturally impaired waterway by VADEQ for dissolved oxygen. The annual median conductivity (49 µS/cm) and total dissolved solids (31.3 mg/L) were the lowest among all sites. The annual median turbidity was 4.9 NTUs. The annual median ammonia nitrogen level was below the method detection limit, <0.02 mg/L as N. The nitrate+nitrite annual median was 0.06 mg/L as N. The phosphate phosphorus annual median was 0.02 mg/L as P. The *E. coli* annual median concentration was <20 CFU/100mL and was among the two lowest median *E. coli* concentrations. The median fluoride concentration was the highest seen among the sites at 0.42 mg/L but still indicated levels similar to groundwater. The potassium annual median was 2.0 mg/L, similar to expected groundwater concentrations.

Site Number WQ-73

Stream: Little Tomahawk Creek

Site: Approximately 50 meters upstream of the Woodland Creek Way crossing, Midlothian, Virginia

Latitude: 37.48887
Longitude: 77.66063

Watershed: Appomattox River

Stream Order: 1

Land use: Residential townhomes and commercial

Gradient: Low

Field and Laboratory Observations:

Date	Dissolved Oxygen (mg/L)	pH (units)	Conductivity (microS/cm)	Total Dissolved Solids (mg/L)	Temperature (Degrees C)	Ammonia (mg/L as N)	Nitrate+Nitrite (mg/L as N)	Phosphate (mg/L as P)	Turbidity (NTUs)	*E. Coli* CFU/100mL	Flow m/s	Index Score %Comparison
01/22/13	12.7	5.9	156	99.9	5.2	<0.02	0.38	<0.02	5.9	*	0.52	73.3
02/12/13	11.9	6.2	157	100.4	8.6	<0.02	0.26	<0.02	5.5	40	0.40	81.3
03/20/13	11.8	6.8	129	82.3	7.3	0.39	0.34	0.02	8.5	*	0.46	46.7
04/22/13	10.6	7.2	122	77.9	11.6	<0.02	0.15	<0.02	5.1	<20	0.42	87.6
05/21/13	8.4	6.6	137	87.2	18.0	0.02	0.16	<0.02	6.3	*	0.40	66.7
06/17/13	8.2	6.3	87	55.5	20.8	0.11	0.22	0.04	32.0	60	0.36	68.3
07/15/13	8.3	6.4	152	97.2	22.1	0.03	0.31	0.02	7.8	*	0.15	73.3
08/12/13	7.8	6.3	141	90.4	23.2	0.02	0.18	<0.02	5.9	420	0.26	81.3
09/16/13	8.4	6.5	157	100.5	16.9	<0.02	0.17	0.02	2.8	*	0.07	86.7
10/22/13	8.8	6.4	153	97.6	14.4	<0.02	0.12	<0.02	2.2	<20	0.09	93.8
11/13/13	8.8	6.4	151	96.3	8.1	<0.02	0.03	0.02	1.5	*	0.02	93.3
12/16/13	11.1	6.8	139	88.4	7.7	0.03	0.58	<0.02	4.4	20	0.21	81.3
Minimum	7.8	5.9	87	55.5	5.2	<0.02	0.03	<0.02	1.5	<20	0.02	46.7
Median	8.8	6.4	146	93.4	13.0	0.02	0.20	<0.02	5.4	30	0.31	81.3
Maximum	12.7	7.2	157	100.5	23.2	0.39	0.58	0.04	32.0	420	0.52	93.8
2012 Median	9.1	6.2	125	80.3	16.4	<0.02	0.13	0.02	3.9	150	0.21	87.5

This was the second consecutive year this sampling site has been evaluated. Little Tomahawk Creek is a perennial tributary in the Appomattox River watershed located in the High River Terrace region of Chesterfield County. The stream's substrate is predominately comprised of sand, gravel and some cobble. The stream exhibited flow throughout the year. The water flowed clear throughout most of the year with once incidence of turbid appearance in June. The stream is heavily eroded with its parent material exposed along the banks and streambed. The riparian area is narrowly treed and shrubbed with a parking lot and apartment complex being its dominant feature. Periphyton and algae were seen at various times throughout the year.

Samples were obtained from the left bank at a median depth of 0.03 meters. The annual median index score (81.3%) indicated moderate chemical water quality; a decrease from the high chemical water quality observed in 2012. All annual median chemical parameters were within acceptable ranges. All dissolved oxygen (annual median 8.8 mg/L) measurements were acceptable but pH (annual median 6.4 units) violated the state water quality standard once during the year. The turbidity annual median was 5.4 NTUs, the highest turbidity observation among all sites occurred at this site in June (32.0 NTUs) supporting the corresponding turbid water observation. The annual median ammonia nitrogen was 0.02 mg/L as N. The nitrate+nitrite annual median was 0.20 mg/L as N. The phosphate phosphorus annual median concentration was one of the two lowest concentrations seen among the sites at <0.02mg/L as P. The median *E. coli* concentration was 30 CFUs/100mL with one violation of the state water quality bacterial standard during the year. The annual median fluoride concentration was 0.20 mg/L, indicating levels similar to groundwater. The potassium annual median (1.7 mg/L) was similar to expected groundwater levels and the lowest observed medians of all sites.

Site Number WQ-74

Stream: Tributary to Falling Creek

Site: Approximately 10 meters downstream of Queensgate Road crossing, Midlothian, Virginia

Latitude: 37.48659
Longitude: 77.64034

Watershed: James River

Stream Order: 1

Land use: Residential and forested park

Gradient: Low

View is downstream

Field and Laboratory Observations:

Date	Dissolved Oxygen (mg/L)	pH (units)	Conductivity (microS/cm)	Total Dissolved Solids (mg/L)	Temperature (Degrees C)	Ammonia (mg/L as N)	Nitrate+Nitrite (mg/L as N)	Phosphate (mg/L as P)	Turbidity (NTUs)	*E. Coli* CFU/100mL	Flow m/s	Index Score %Comparison
01/22/13	12.2	5.9	156	99.2	5.1	0.06	0.35	0.03	9.6	*	0.17	53.3
02/12/13	12.0	6.2	232	148.5	8.3	<0.02	0.31	<0.02	6.6	20	0.19	81.3
03/20/13	11.6	6.9	191	122.0	8.6	0.13	0.36	0.02	8.7	*	0.12	60.0
04/22/13	9.6	6.7	165	105.4	13.3	0.05	0.16	<0.02	4.6	80	0.15	87.5
05/21/13	7.1	6.6	152	97.1	20.4	0.02	0.17	<0.02	4.0	*	0.14	93.3
06/17/13	7.0	6.4	103	65.9	22.9	0.06	0.13	0.02	8.1	20	0.24	68.8
07/15/13	7.1	6.5	112	71.5	25.1	0.04	0.14	0.03	3.5	*	0.10	86.7
08/12/13	6.9	6.4	101	64.7	25.1	0.03	0.11	0.03	2.6	6700	0.07	81.3
09/18/13	8.0	6.5	147	93.7	15.7	0.05	0.13	0.03	3.3	*	<0.01	80.0
10/22/13	8.1	6.5	148	93.9	12.5	<0.02	0.07	0.03	2.6	20	<0.01	93.8
11/13/13	5.3	6.6	169	108.7	6.7	<0.02	0.06	0.08	3.5	*	<0.01	93.3
12/18/13	10.5	6.9	117	74.8	8.1	0.25	0.26	0.02	6.4	140	0.21	56.3
Minimum	5.3	5.9	101	64.7	5.1	<0.02	0.06	<0.02	2.6	20	<0.01	53.3
Median	**7.6**	**6.5**	**150**	**95.5**	**12.9**	**0.05**	**0.15**	**0.03**	**4.3**	**50**	**0.13**	**81.3**
Maximum	12.2	6.9	232	148.5	25.1	0.25	0.36	0.08	9.6	6700	0.24	93.8
2012 Median	**7.5**	**6.4**	**133**	**85.2**	**18.5**	**0.03**	**0.15**	**0.02**	**6.5**	**150**	**0.09**	**74.2**

This was the second consecutive year this sampling site has been evaluated. Tributary to Falling Creek is a perennial tributary in the James River watershed located in the Piedmont and Alluvium region of Chesterfield County. The creek's substrate is comprised of sand, gravel and some cobble/rip rap at the top of the sampling reach. Flow was observed during most of the year with water consistently present, but flow was immeasurable on three sampling events (September, October and November). The stream appeared clear throughout most of the year with two observations of staining. The banks were well vegetated and were slightly to moderately eroded. The riparian area vegetation consisted of trees and shrubs with herbaceous growth seen during the summer season. The riparian corridor was narrow and both sides flanked by residential yards. Periphyton was observed during each visit and algae, iron bacteria, frogs and fish were also observed during the year.

Samples were obtained from the right bank at a median depth of 0.18 meters. The annual median index score (81.3%) indicated moderate chemical water quality. All annual medians of the chemical parameters were within acceptable ranges. There were no violations of the dissolved oxygen state water quality standard but pH violated the standard once in January. The annual median conductivity (150 µS/cm) and total dissolved solids (95.5 mg/L) were the highest among all sites. The turbidity annual median was 4.3 NTUs. The annual median ammonia nitrogen concentration was 0.05 mg/L as N. The annual median nitrate+nitrite concentration was 0.15 mg/L as N. The phosphate phosphorus annual median concentration was 0.03mg/L as P. The median *E. coli* concentration was 50 CFUs/100mL with one violation of the state water quality bacterial standard in August (6700 CFUs/100mL). An investigation was triggered and resulted in finding and repairing an upstream sewer line break. The median fluoride concentration was 0.29 mg/L indicating levels similar to expected groundwater levels. The potassium annual median (2.6 mg/L) was the highest seen among the sites but still similar to expected groundwater levels.

Site Number WQ-75

Stream: Powhite Creek

Site: Approximately 30 meters upstream of White Rabbit Road crossing, Bon Air, Virginia

Latitude: 37.52377
Longitude: 77.58997

Watershed: James River

Stream Order: 1

Land use: Residential and forested areas

Gradient: Low

Field and Laboratory Observations:

Date	Dissolved Oxygen (mg/L)	pH (units)	Conductivity (microS/cm)	Total Dissolved Solids (mg/L)	Temperature (Degrees C)	Ammonia (mg/L as N)	Nitrate+Nitrite (mg/L as N)	Phosphate (mg/L as P)	Turbidity (NTUs)	*E. Coli* CFU/100mL	Flow m/s	Index Score %Comparison
01/22/13	12.4	6.2	118	75.9	5.2	0.04	0.43	<0.02	6.6	*	0.52	80.0
02/12/13	12.4	6.6	134	86.1	8.9	<0.02	0.28	<0.02	4.0	<20	0.38	87.5
03/20/13	12.0	6.9	113	72.7	8.7	0.43	0.23	0.02	9.3	*	0.89	46.7
04/22/13	9.9	6.4	125	79.7	12.0	0.02	0.19	<0.02	4.0	<20	0.29	93.8
05/21/13	7.4	6.4	121	77.5	19.4	0.03	0.22	0.02	4.9	*	0.65	80.0
06/17/13	6.9	6.2	94	60.1	21.2	0.09	0.22	0.05	8.2	140	0.62	62.5
07/15/13	7.4	6.3	116	74.5	24.1	0.05	0.21	0.03	5.0	*	0.21	73.3
08/12/13	7.3	6.4	109	70.1	24.7	0.03	0.13	0.02	4.6	120	0.16	87.5
09/18/13	8.0	6.5	127	81.4	16.6	0.02	0.24	0.02	4.8	*	0.05	80.0
10/22/13	9.0	6.8	112	71.4	13.1	<0.02	0.14	0.02	3.8	80	0.12	87.5
11/13/13	5.9	6.5	97	62.4	7.0	<0.02	0.03	0.04	2.5	*	0.14	93.3
12/16/13	11.5	7.0	100	64.2	6.7	0.03	0.37	<0.02	5.2	240	0.80	75.0
Minimum	5.9	6.2	94	60.1	5.2	<0.02	0.03	<0.02	2.5	<20	0.05	46.7
Median	8.5	6.5	115	73.6	12.5	0.03	0.22	0.02	4.9	90	0.34	80.0
Maximum	12.4	7.0	134	86.1	24.7	0.43	0.43	0.05	9.3	240	0.89	93.8
2012 Median	8.1	6.4	116	74.2	16.2	0.03	0.19	0.04	4.1	50	0.21	81.3

This was the second consecutive year this sampling site has been evaluated and is approximately two and a half miles upstream of the sampling site Powhite Creek WQ-70. Powhite Creek is a perennial tributary of the James River and this upper segment is located in the High River Terrace region of Chesterfield County. The stream substrate is comprised of sand, gravel and cobble. The stream bed had large extensive sand/gravel bars that were exposed during most of the year and can be seen in the above photo. This creek exhibited strong, measurable flow throughout the year. The water was observed as clear during the year. The banks were well vegetated appearing slightly eroded. The riparian area consisted of trees and shrubs with herbaceous growth present during the summer months. Periphyton was observed throughout the year along with observations of algae and iron bacteria.

Samples were obtained from the left bank at a median depth of 0.08 meters. The annual median index score (80.0%) indicated moderate chemical water quality. As with the Powhite Creek WQ-70 site downstream, all annual medians of the chemical parameters were within acceptable ranges. There were no instances of dissolved oxygen concentrations (annual median 8.5 mg/L) or pH (annual median 6.5 units) violating state standards. The annual median conductivity (115 µS/cm) and total dissolved solids (73.6 mg/L) were similar to the annual medians observed at the downstream Powhite Creek (WQ-70) sampling location. The annual median turbidity was 4.9 NTUs, supporting the observations of clear water. The annual median ammonia nitrogen concentration was 0.03 mg/L as N. The annual median nitrate+nitrite concentration was 0.22 mg/L as N. The phosphate phosphorus annual median was 0.02 mg/L as P. The annual median *E. coli* was 90 CFUs/100mL, the highest among all sites, with one violation in the state bacterial water standard during the year. The median fluoride concentration was 0.29 mg/L indicating levels similar to expected groundwater levels. The potassium annual median (2.2 mg/L) was also similar to expected groundwater levels.

Site Number WQ-76

Stream: Tributary to Falling Creek

Site: Approximately 10 meters downstream Barkbridge Road crossing, North Richmond, Virginia

Latitude: 37.44195
Longitude: 77.52907

Watershed: James River

Stream Order: 2

Land use: Residential and forested

Gradient: Low:

View is downstream

Field and Laboratory Observations:

Date	Dissolved Oxygen (mg/L)	pH (units)	Conductivity (microS/cm)	Total Dissolved Solids (mg/L)	Temperature (Degrees C)	Ammonia (mg/L as N)	Nitrate+Nitrite (mg/L as N)	Phosphate (mg/L as P)	Turbidity (NTUs)	*E. Coli* CFU/100mL	Flow m/s	Index Score %Comparison
01/22/13	12.1	5.8	148	94.1	4.8	0.17	0.29	0.03	13.7	*	0.20	40.0
02/12/13	11.6	6.0	170	108.1	8.0	<0.02	0.17	0.03	12.5	20	0.27	68.8
03/20/13	11.1	6.6	118	75.6	8.2	0.03	0.14	0.03	11.0	*	0.23	73.3
04/22/13	8.8	6.5	109	69.9	13.8	0.04	0.16	<0.02	8.9	20	0.12	81.3
05/21/13	6.3	6.4	97	62.3	21.8	0.05	0.17	0.05	6.9	*	0.09	73.3
06/17/13	5.3	6.2	96	61.4	22.3	0.18	0.17	0.08	6.0	20	0.09	66.8
07/15/13	6.5	6.9	74	47.5	23.1	0.05	0.15	0.06	6.8	*	0.17	60.0
08/12/13	4.2	6.4	82	52.6	24.6	0.06	0.14	0.03	4.7	60	0.09	81.3
09/18/13	7.3	6.5	88	56.3	16.1	0.03	0.16	0.04	5.7	*	0.05	80.0
10/22/13	7.3	6.7	87	55.6	13.1	<0.02	0.10	0.04	4.0	20	0.09	93.8
11/13/13	7.9	6.5	96	61.1	6.7	<0.02	0.06	0.05	3.8	*	0.10	93.3
12/16/13	10.8	6.9	108	69.0	5.4	0.02	0.23	0.05	12.5	280	0.22	55.3
Minimum	4.2	5.8	74	47.5	4.8	<0.02	0.06	<0.02	3.8	20	0.05	40.0
Median	7.6	6.4	97	61.9	13.4	0.04	0.17	0.04	7.9	20	0.11	73.3
Maximum	12.1	6.9	170	108.1	25.1	0.18	0.29	0.08	13.7	280	0.27	93.8
2012 Median	6.5	6.3	87	55.8	17.9	0.05	0.19	0.05	5.6	60	0.05	74.2

This was the second consecutive year this sampling site has been evaluated. Tributary to Falling Creek is a perennial tributary in the James River watershed located in the Piedmont and Alluvium region of Chesterfield County. The stream substrate is comprised of sand, gravel and cobble. The stream exhibited strong, measurable flow throughout the year. The water appeared stained during the majority of the year and clear on four visits. The stream appears slight to moderately eroded. The riparian area consists of trees and shrubs with herbaceous growth noted during the warmer months. Considering the site's location in an older residential neighborhood, and when compared to other creeks in similar locations such as Timsbury Creek WQ-78, the riparian area appears relatively undisturbed. Several different instream biotas were observed at this location including: periphyton, algae, emergent plants, *Corbicula* shells and water striders.

Samples were obtained from the left bank at a median depth of 0.18 meters. The annual median index score (73.3%) indicated moderate chemical water quality. All annual medians of the chemical parameters were within acceptable ranges. The dissolve oxygen concentration did not violate state water quality standards during the year. However, pH (annual median 6.4 units) violated the state water quality standard twice in January and July. The annual median turbidity was 7.9 NTUs and was the highest annual median among all sites. The annual ammonia nitrogen median concentration was 0.04 mg/L as N. The nitrate+nitrite annual median was 0.17 mg/L as N. The annual phosphate phosphorus median concentration was 0.04 mg/L as P. The median *E. coli* concentration was 20 CFUs/100mL with one violation in the state bacterial water standard. The annual median fluoride concentration was 0.31 mg/L. The potassium annual median was 2.4 mg/L. Both the fluoride and potassium annual median concentrations were consistent with expected results for groundwater.

Site Number WQ-77

Stream: Tributary to Proctors Creek

Site: Approximately 50 meters downhill & west of school complex on Salem Church Road, Chesterfield, Virginia

Latitude: 37.38239
Longitude: 77.48666

Watershed: James River

Stream Order: 1

Land use: Forested residential with an adjacent county school complex

Gradient: Low

Field and Laboratory Observations:

Date	Dissolved Oxygen (mg/L)	pH (units)	Conductivity (microS/cm)	Total Dissolved Solids (mg/L)	Temperature (Degrees C)	Ammonia (mg/L as N)	Nitrate+Nitrite (mg/L as N)	Phosphate (mg/L as P)	Turbidity (NTUs)	*E. Coli* CFU/100mL	Flow m/s	Index Score %Comparison
01/22/13	11.2	5.8	76	48.3	4.7	0.03	0.34	0.03	5.2	*	0.08	66.7
02/12/13	10.1	5.9	83	52.9	10.0	<0.02	0.29	0.02	5.1	<20	0.10	68.8
03/20/13	10.8	6.1	71	45.3	9.2	0.04	0.30	0.05	5.9	*	0.14	73.3
04/22/13	9.1	6.1	67	43.0	11.7	0.04	0.29	<0.02	5.0	20	0.06	81.3
05/21/13	6.3	5.9	65	41.9	18.6	0.05	0.46	0.03	6.3	*	0.13	53.3
06/17/13	6.0	6.0	78	49.7	20.8	0.16	0.23	0.03	10.4	160	0.27	62.5
07/15/13	6.2	6.1	80	51.1	23.8	0.05	0.41	0.05	8.3	*	0.05	60.0
08/12/13	5.6	6.0	72	45.8	24.9	0.02	0.36	0.03	5.6	160	0.03	75.0
09/16/13	6.9	6.1	60	38.3	16.1	<0.02	0.45	0.04	3.5	*	<0.01	80.0
10/22/13	7.4	6.5	86	54.8	13.4	<0.02	0.22	0.02	2.7	20	<0.01	81.3
11/13/13	8.6	6.4	83	53.2	6.7	<0.02	0.02	0.03	2.3	*	<0.01	93.3
12/16/13	9.5	6.8	70	45.0	7.0	0.03	0.45	0.02	7.9	<20	0.10	75.0
Minimum	5.6	5.8	60	38.3	4.7	<0.02	0.02	<0.02	2.3	<20	<0.01	53.3
Median	7.1	6.1	74	47.1	12.5	0.03	0.32	0.03	5.3	20	0.09	74.2
Maximum	11.2	6.8	86	54.8	24.9	0.16	0.48	0.05	10.4	160	0.27	93.3
2012 Median	6.2	6.0	62	40.0	17.3	0.04	0.23	0.05	6.7	90	<0.01	71.0

This was the second consecutive year this sampling site has been evaluated. Tributary to Proctors Creek is a perennial tributary in the James River watershed located in the Deep Coastal Plain region of Chesterfield County. The creek's substrate consists of soft silt and clay with some sand. While water was consistently present, flow tended to be slow with three occasions when it was not measurable. The water clarity varied throughout the year appearing clear, stained and turbid at various times. Bank erosion along this languid creek was slight to none. The riparian area was forested with undergrowth shrubs and some herbaceous cover. The riparian cover along this creek supplied abundant allochthonous input to the creek throughout the year. Periphyton was observed throughout the year. Additional biotas observed included algae, submergent plants and water striders.

Samples were obtained from the right bank at a median depth of 0.13 meters. The annual median index score (74.2%) indicated moderate chemical water quality. All annual medians of the chemical parameters were within acceptable ranges. The dissolve oxygen concentration did not violate state water quality standards during the year. However, pH (annual median 6.1 units) violated the state water quality standard three times during the year. The annual median turbidity was 5.3 NTUs. The nitrogen nutrient concentrations at this site were slightly elevated. The median ammonia nitrogen concentration was 0.03 mg/L as N. The nitrate+nitrogen annual median was 0.32mg/L as N, the second highest annual median observed among all sites. The phosphate phosphorus annual median was 0.03 mg/L as P. The annual median *E. coli* concentration was 20 CFUs/100mL. The median fluoride concentration was below the reporting limit 0.15 mg/L indicating levels similar to expected groundwater levels. The potassium annual median (2.0 mg/L) was also similar to expected groundwater levels.

Site Number WQ-78

Stream: Timsbury Creek

Site: Approximately 15 meters downstream of Cedar Cliff Drive road crossing, Chester, Virginia

Latitude: 37.32422
Longitude: 77.44601

Watershed: Appomattox River

Stream Order: 3

Land use: Residential with adjacent neighborhood park

Gradient: Low

View is downstream

Field and Laboratory Observations:

Date	Dissolved Oxygen (mg/L)	pH (units)	Conductivity (microS/cm)	Total Dissolved Solids (mg/L)	Temperature (Degrees C)	Ammonia (mg/L as N)	Nitrate+Nitrite (mg/L as N)	Phosphate (mg/L as P)	Turbidity (NTUs)	*E. Coli* CFU/100mL	Flow m/s	Index Score %Comparision
01/22/13	11.8	5.5	67	43.0	5.6	0.08	0.38	<0.02	6.2	*	0.40	66.7
02/12/13	11.1	5.7	66	42.2	9.8	0.03	0.30	<0.02	5.8	<20	0.33	75.0
03/20/13	10.8	6.0	27	17.5	10.4	0.08	0.33	<0.02	7.0	*	0.35	73.3
04/22/13	9.3	6.1	66	42.5	14.3	0.04	0.27	<0.02	8.2	60	0.37	75.0
05/21/13	7.2	5.9	110	70.4	20.6	0.05	0.32	<0.02	9.5	*	0.22	60.0
06/17/13	6.8	6.0	86	54.8	21.9	0.29	0.34	0.04	27.7	200	0.43	43.8
07/15/13	6.9	5.8	72	46.3	25.5	0.07	0.35	0.02	7.9	*	0.29	60.0
08/12/13	6.8	6.0	80	50.9	25.2	0.05	0.31	<0.02	6.9	280	0.20	68.8
09/18/13	8.2	6.0	74	47.4	16.9	0.02	0.36	0.04	5.1	*	0.31	73.3
10/22/13	8.2	6.3	86	55.6	13.9	<0.02	0.29	<0.02	4.3	40	0.27	87.5
11/13/13	6.0	6.0	79	50.2	6.8	<0.02	0.22	0.02	4.3	*	0.17	80.0
12/16/13	10.0	6.7	63	40.5	7.0	0.24	0.45	0.02	6.1	60	0.48	62.5
Minimum	6.0	5.5	27	17.5	5.6	<0.02	0.22	<0.02	4.3	<20	0.17	43.8
Median	**8.2**	**6.0**	**73**	**46.9**	**14.1**	**0.05**	**0.33**	**<0.02**	**6.6**	**60**	**0.32**	**71.0**
Maximum	11.8	6.7	110	70.4	25.5	0.29	0.45	0.04	27.7	280	0.48	87.5
2012 Median	**7.7**	**6.0**	**77**	**49.3**	**18.7**	**0.07**	**0.22**	**0.02**	**9.4**	**20**	**0.25**	**64.6**

This was the second consecutive year this sampling site has been evaluated. Timsbury Creek is a perennial tributary to the Appomattox River located in the Deep Coastal Plain region of Chesterfield County. The stream's substrate is comprised of sand and gravel with intermixed cobble along the top of the reach. Flow at this site was strong and observable throughout the year. The water appeared stained or clear throughout the year. The banks were moderately eroded. The creek is bordered by a neighborhood park along the left bank and houses along the right. The width of the natural riparian area along both sides of the creek is approximately 10 meters. The natural riparian area is comprised of trees, grass and some shrub growth. Periphyton was the most often observed biota; algae, iron bacteria, submergent and emergent plants were also observed.

Samples were obtained from the right bank at a median depth of 0.15 meters. The annual median index score (71.0%) indicated moderate chemical water quality. All annual medians of the chemical parameters were within acceptable ranges. On four observations, pH (annual median 6.0 units) violated the state water quality standards. There were no violations of the state dissolved oxygen standard. The annual median turbidity was 6.6 NTUs. The annual median ammonia nitrogen concentration was 0.05 mg/L as N. The highest annual median nitrate+nitrite concentration (0.33 mg/L as N) was observed at this site. The phosphate phosphorus annual median concentration was among the two lowest concentrations seen among the sites at <0.02 mg/L as P. The *E. coli* median concentration was 60 CFUs/100mL with one violation of the state bacterial standard during the year. The annual median fluoride value was below the reporting limit 0.15 mg/L. The potassium annual median was 2.4 mg/L. Both the fluoride and potassium annual median concentrations were consistent with expected results for groundwater.

Site Number WQ-79

Stream: Tributary to Timsbury Creek

Site: Approximately 10 meters downstream of Harrowgate Road crossing, South Chesterfield, Virginia

Latitude: 37.29478
Longitude: 77.42186

Watershed: Appomattox River

Stream Order: 2

Land use: Forested residential

Gradient: Low

View is downstream

Field and Laboratory Observations:

Date	Dissolved Oxygen (mg/L)	pH (units)	Conductivity (microS/cm)	Total Dissolved Solids (mg/L)	Temperature (Degrees C)	Ammonia (mg/L as N)	Nitrate+Nitrite (mg/L as N)	Phosphate (mg/L as P)	Turbidity (NTUs)	*E. Coli* CFU/100mL	Flow m/s	Index Score %Comparision
01/22/13	11.6	4.5	54	34.6	4.5	0.05	0.27	0.02	6.1	*	0.35	60.0
02/12/13	10.9	4.6	54	34.5	9.3	<0.02	0.16	<0.02	6.3	<20	0.34	81.3
03/20/13	11.3	5.3	51	32.6	8.6	0.02	0.16	0.02	7.2	*	0.25	73.3
04/22/13	9.2	5.5	48	30.9	12.4	0.02	0.24	<0.02	9.4	80	0.21	68.8
05/21/13	6.8	5.6	59	37.4	19.7	0.11	0.24	0.03	9.1	*	0.30	46.7
06/17/13	5.9	5.3	58	36.2	21.4	0.15	0.27	0.05	9.9	620	0.11	50.0
07/15/13	6.4	5.5	63	39.0	24.7	0.10	0.30	0.08	8.6	*	0.18	53.3
08/12/13	6.8	5.8	69	44.9	25.6	0.07	0.45	0.05	12.2	240	0.19	43.8
09/18/13	6.9	6.2	80	51.4	17.1	<0.02	0.84	0.05	5.5	*	<0.01	66.7
10/22/13	7.9	5.8	74	46.5	14.0	<0.02	0.17	0.02	5.4	<20	0.07	75.0
11/13/13	4.4	6.1	81	51.7	7.6	0.02	0.33	0.02	3.8	*	0.10	80.0
12/16/13	11.6	5.7	57	36.5	6.3	<0.02	0.16	0.02	6.5	60	0.27	75.0
Minimum	4.4	4.5	48	30.9	4.5	<0.02	0.16	<0.02	3.8	<20	<0.01	43.8
Median	**7.4**	**5.5**	**58**	**37.0**	**13.2**	**0.02**	**0.26**	**0.02**	**6.9**	**70**	**0.20**	**67.7**
Maximum	11.6	6.2	81	51.7	25.6	0.15	0.84	0.08	12.2	620	0.35	81.3
2012 Median	**7.6**	**5.8**	**69**	**44.2**	**18.0**	**0.02**	**0.28**	**0.04**	**7.5**	**60**	**0.12**	**66.7**

This was the second consecutive year this sampling site has been evaluated. Tributary to Timsbury Creek is a perennial tributary in the Appomattox River watershed located in the Deep Coastal Plain region of Chesterfield County. Just upstream of the sampling location, a roadside tributary merges with the main branch of this Timsbury Creek tributary. The stream's substrate consists of sand, gravel and cobble. The stream exhibited strong flows throughout the year. The water appeared stained during ten of the twelve site visits. The stream banks were well vegetated and only slightly eroded. The riparian area consisted of trees and shrubs with herbaceous growth noted during the summer months. Periphyton was observed throughout most of the year. Additionally seen were algae, submergent plants and multiple macroinvertebrates.

Samples were obtained from the left bank at a median depth of 0.13 meters. The annual median index score (67.7%) indicated low chemical water quality. The low chemical water quality score can be attributed to elevated nitrate+nitrite nitrogen and phosphate phosphorus concentrations and violations of the state pH and *E. coli* water quality standard. All annual medians of the chemical parameters were within acceptable ranges except pH. The annual median pH (5.5 units) violated the state water quality standard. On ten occasions the pH at this location was below the state standard. The annual median dissolved oxygen concentration was 7.4 mg/L and there were no violations of the state water quality standard throughout the year. The annual median ammonia nitrogen concentration was 0.02 mg/L as N. The annual median nitrate+nitrite concentration was 0.26 mg/L as N. The phosphate phosphorus annual median concentration was 0.02 mg/L as P. The *E. coli* annual median concentration was 70 CFUs/100mL with two violations in the state bacterial water quality standard in June and August. The annual median fluoride value was 0.22 mg/L. The potassium annual median was 2.4 mg/L. Both the fluoride and potassium annual median concentrations were consistent with expected results for groundwater.

Discussion

A review of the annual median chemical water quality index values revealed that nine of the streams monitored in 2013 were characterized as having moderate or high water quality (Table 2). Low water quality was observed at one monitoring station (Table 2).

Table 2. Annual chemical water quality categorical observations for 10 streams of Chesterfield County, 2013

Site Number	Stream	Annual Median Score	Category
27	Turkey Creek	93.3	High Quality
70	Powhite Creek	80.6	Moderate Quality
71	Winterpock Creek	81.3	Moderate Quality
73	Little Tomahawk Creek	81.3	Moderate Quality
74	Trib to Falling Creek	81.3	Moderate Quality
75	Powhite Creek	80.0	Moderate Quality
76	Trib to Falling Creek	73.3	Moderate Quality
77	Trib to Proctor's Creek	74.2	Moderate Quality
78	Timsbury Creek	71.0	Moderate Quality
79	Trib to Timsbury Creek	67.7	Low Quality

High chemical water quality was observed at one site (Turkey Creek WQ-27) during 2013 (Table 2). Distinguishing characteristics of this stream's chemistries included repeated combinations of low nutrient concentrations of nitrogen and phosphorus with excellent water clarity as indicated by low turbidity. At this site, the annual median concentration of ammonia nitrogen was 0.02 mg/L. The nitrate+nitrite annual median concentration (0.05 mg/L as N) was the lowest among all creeks observed in 2013. The annual median phosphate phosphorus concentration was of moderate quality with an annual median of 0.04 mg/L as P. Water clarity at the one site with high chemical water quality was also excellent with the all of turbidity readings less than 6.0 NTUs and annual median of 4.2 NTUs.

Low chemical water quality was observed at one stream site during 2013, Tributary to Timsbury Creek WQ-79. This was the second consecutive year low chemical water quality was observed at this site. Generally low chemical water quality was attributed to elevated concentrations of nutrients, violations of the state's water quality pH standard and elevated turbidity. Consistently elevated nitrate+nitrogen and phosphate phosphorus concentrations, elevated turbidity readings and ten pH standard violations were observed at Tributary to Timsbury Creek WQ-79.

Table 3. Annual median values for water quality parameters, 2013. Values in red indicate observations that did not meet ideal benchmarks or standards.

Site	Dissolved Oxygen (mg/L)	pH (units)	Conductivity (microS/cm)	Total Dissolved Solids (mg/L)	Temperature (Degrees C)	Ammonia (mg/L as N)	Nitrate+Nitrite (mg/L as N)	Phosphate (mg/L as P)	Turbidity (NTUs)	*E. Coli* CFU/100mL	Fluoride (mg/L)	Potassium (mg/L)	Flow m/s	Sample Depth (m)	Air Temp °C
WQ-27	8.0	6.4	57	36.5	10.2	0.02	0.05	0.04	4.2	20	0.41	2.2	0.16	0.07	15
WQ-70	8.1	6.6	121	77.2	13.4	0.08	0.14	0.05	5.2	<20	0.15	2.2	0.08	0.15	15
WQ-71	8.1	5.4	49	31.3	10.7	<0.02	0.06	0.02	4.9	<20	0.42	2.0	0.32	0.04	14
WQ-73	8.8	6.4	146	93.4	13.0	0.02	0.20	<0.02	5.4	30	0.20	1.7	0.31	0.03	12
WQ-74	7.6	6.5	150	95.5	12.9	0.05	0.15	0.03	4.3	50	0.29	2.6	0.15	0.18	13
WQ-75	8.5	6.5	115	73.6	12.5	0.03	0.22	0.02	4.9	90	0.29	2.2	0.34	0.08	14
WQ-76	7.6	6.4	97	61.9	13.4	0.04	0.17	0.04	7.9	20	0.31	2.4	0.11	0.18	15
WQ-77	7.1	6.1	74	47.1	12.5	0.03	0.32	0.03	5.3	20	<0.15	2.0	0.10	0.13	16
WQ-78	8.2	6.0	73	46.9	14.1	0.05	0.33	<0.02	6.6	60	<0.15	2.4	0.32	0.15	17
WQ-79	7.4	5.5	58	37.0	13.2	0.02	0.26	0.02	6.9	70	0.22	2.4	0.21	0.13	18

In 2013, all monitored streams had annual median dissolved oxygen concentrations that met the state water quality standard of greater than or equal to 4.0 mg/L (Table 3). One site (Winterpock Creek WQ-71) had a total of three occurrences when dissolved oxygen concentrations failed to meet the state water quality standard. Each of the three standard violation occurred when flow was immeasurable in the creek. This is not an uncommon observation in when flow is low. The water in the creek would not have been able to properly aerate as a result of low flow. The remaining sites had no violations of the state dissolved oxygen standard.

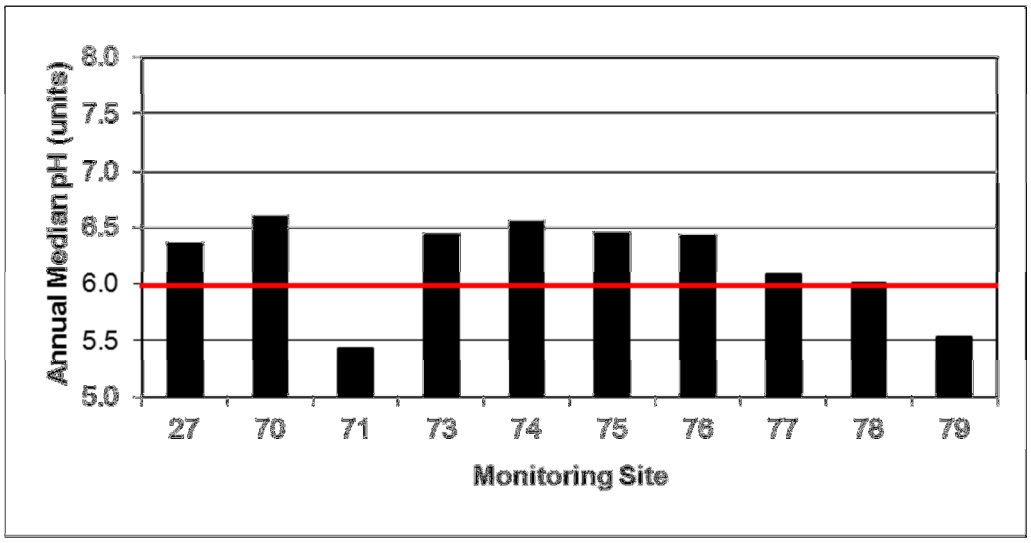

Figure 2. Annual median pH observations among 10 sites within Chesterfield County, 2013. The red bar represents Virginia Department of Environmental Quality's minimum value water quality standard (6.0 units).

In 2013, eight of the ten streams had annual median pH values that were at or above the minimum state water quality standard of 6.0 units (Figure 2). Of the eight sites with median values above 6.0 units, six sites experienced one or more instances of pH dropping below the

state water quality minimum during the year. Winterpock Creek WQ-71 had the most observations of low pH with all twelve measurements less than 6.0 units. The cause for these observations is currently unknown since the watershed is comprised of primarily of forested areas and with some rural residential homes. Depressed pH may be a natural condition of this tributary as a result of upstream wetlands driving down the pH as a result of the natural biologic activities that occur in wetlands. As mentioned in previous reports, the periodic low readings at these sites are not alarming. Low pH is typical of many streams in Virginia due to natural acidity of the surrounding soils and organic acids synthesized and released during decomposition of leaf litter and other plant matter. No sites surpassed the state standard maximum pH limit of 9.0 units during 2013.

Annual median values for specific conductivity and total dissolved solids were within acceptable limits for 2013. Tributary to Falling Creek WQ-74 had the greatest annual median conductivity (150 µS/cm) and total dissolved solids (95.5 mg/L) values compared among the sites. The lowest annual median conductivity and total dissolved solids among all sites were observed at Winterpock Creek WQ-71 with 49 µS/cm and 31.3 mg/L, respectively. Overall, conductivity and total dissolved solids measurements among all sites throughout the year were similar to values observed in previous years.

At all sites, in-stream temperature varied normally according to season ranging among sites from 2.6 to 26.6^{o} C and there were no observations that violated state water quality standards. Ambient air temperature during the surveys also varied seasonally with the year's survey results ranging from 0 to 30^{o} C.

Rainfall for 2013, as reported by the Addison-Evans Water Treatment and Laboratory Facility, was approximately 48.8 inches; 4 inches above normal (average rainfall = 44 inches/year) for this area. Rainfall during most of the year was as expected but rainfall during the fall months was below average for the season. This seasonal rain deficit is most likely the cause for multiple streams having low flow measurements during the September to November timeframe. The least amount of rain was recorded in September with just over 1 inch of rain reported (1.29 inches). The highest monthly rainfall total was recorded in June with 8.24 inches.

Flow varied throughout the year at all sites during 2013. Flows were strong during most of the year with the exception of the fall season during which it became depressed due to the lack of rain in the region. Half of the sampling sites exhibited measureable flow throughout the year: Powhite Creek WQ-70, Little Tomahawk Creek WQ-73, Powhite Creek WQ-75, Tributary to Falling Creek WQ-76 and Timsbury Creek WQ-78. The majority of the flow at these creeks was consistently above 0.10 m/s. The remaining half of the streams sites, experienced at least one instance of low flow (<0.01 m/s) conditions during 2013. All of the low flow events occurred during the dry fall months (September-November). Despite the low flow readings, none of the streams appeared dry during the year.

Overall fluoride concentrations measured throughout the year indicated the streams sampled were not experiencing an intrusion of potable or waste water at the time of sampling. Two of the ten monitoring sites had annual median fluoride concentrations below the reporting limit 0.15 mg/L. All other annual medians were less than or equal to 0.42 mg/L. The greatest fluoride

concentration was observed at Turkey Creek WQ-27 (0.57 mg/L) in March. This concentration was greater than expected in groundwater concentrations but approximately less than the expected drinking water concentration (0.66 mg/L). All other fluoride measurements at WQ-27 were within expectations for groundwater. Therefore, potable water or sewage intrusion was not suspected at this site.

Annual median potassium levels at each stream site were below concentrations that would indicate an illicit connection or discharge into the creek at the time of sampling. The greatest potassium concentration occurred in October at Tributary to Falling Creek WQ-76 measuring 2.9 mg/L. These results indicate that the concentration of potassium in county groundwater trends with the expected result of 3.1 mg/L.

Overall, ammonia nitrogen median concentrations were at acceptable levels during 2013 with three streams' annual median values greater than 0.04 mg/L as N (Powhite Creek WQ-70, Tributary to Falling Creek WQ-74 and Timsbury Creek WQ-78; Table 3). The greatest annual ammonia nitrogen median was noted at Powhite Creek WQ-70 (0.08 mg/L as N). The single greatest ammonia nitrogen level measured during 2013 (0.51 mg/L as N) was recorded in December at Powhite Creek WQ-70. The lowest annual median concentration (<0.02 mg/L as N) was recorded at one site: Winterpock Creek WQ-71.

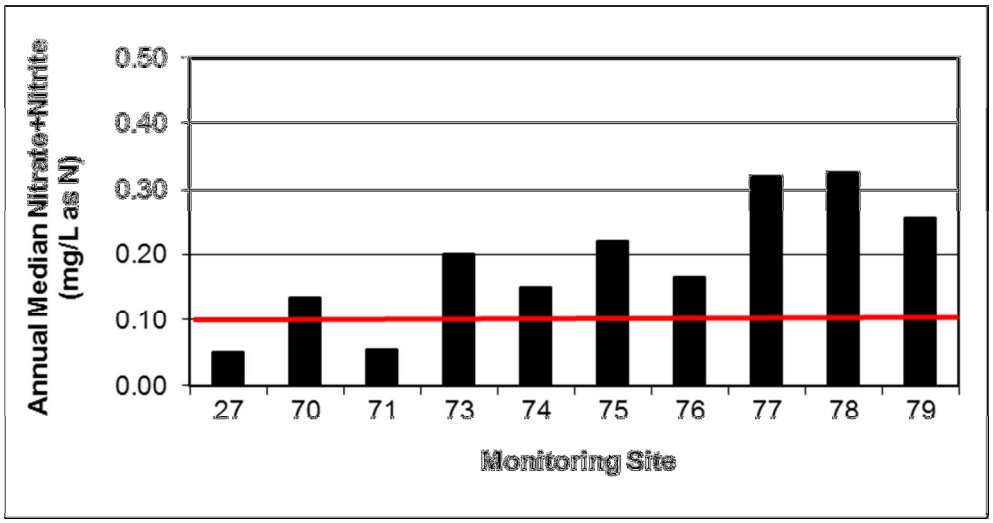

Figure 3. Annual median nitrate+nitrite nitrogen observations among 10 sites within Chesterfield County, 2013. The red bar represents the USEPA's local reference condition for Level III Ecoregion 45 streams (0.10mg/L as N).

Annual median nitrate+nitrite nitrogen concentrations were generally elevated among all sites in 2013. During the monitoring year, eight of the ten monitored sites had annual median concentrations greater than 0.10 mg/L as N (USEPA's reference condition for this ecoregion; Figure 3). Tributary to Timsbury Creek WQ-78 had the highest annual median concentration of nitrate+nitrite (0.33 mg/L as N). In September, the greatest individual measurement of nitrate+nitrite nitrogen (0.84 mg/L as N) was recorded at Tributary to Timsbury Creek WQ-79, the only stream to score in the low quality category during this monitoring year. The two sites with concentrations of nitrate+nitrite nitrogen below 0.10 mg/L as N were Turkey Creek WQ-27

Winterpock Creek WQ-71 and with annual medians of 0.05 mg/L as N and 0.06 mg/L as N, respectively. Nitrate+nitrite nitrogen has continued to be the most frequently observed pollutant in Chesterfield County's monitored streams.

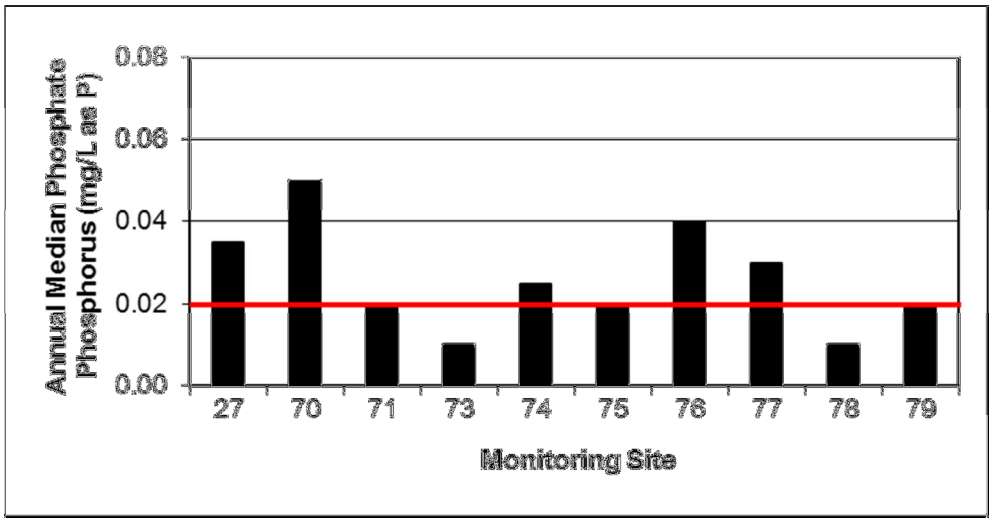

Figure 4. Annual median phosphate phosphorus observations among 10 sites within Chesterfield County, 2013. The red bar represents the Center for Watershed Protection's published ideal value for forested systems (0.02mg/L as P).

Annual median concentrations of phosphate phosphorus were elevated in eight of the ten streams monitored during 2013 with concentrations greater than or equal to 0.02 mg/L as P (Figure 4). The greatest annual median concentration (0.05 mg/L as P) was observed at Powhite Creek WQ-70. This site drains a large residential area and it is suspected that the source of the nutrient elevation is the effect of fertilizer use on lawns in the watershed. Eight of the sites had phosphate phosphorus concentrations during the year greater than or equal to 0.05 mg/L as P. The greatest individual measurement of phosphate phosphorus was recorded during March at Powhite Creek WQ-70 (0.10 mg/L as P). Three streams had annual median phosphate phosphorus concentrations of 0.02mg/L as P: Winterpock Creek WQ-71, Powhite Creek WQ-75 and Tributary to Timsbury Creek WQ-79. The two streams with annual medians that met the benchmark for the ideal phosphate phosphorus concentration value (<0.02 mg/L as P) were Little Tomahawk Creek WQ-73 and Timsbury Creek WQ-78. As with nitrate+nitrite nitrogen, phosphate phosphorus remains a commonly observed pollutant throughout the county.

All annual median *E. coli* colony concentrations were below the state bacteria water quality standard of 235 CFUs/100mL. VADEQ criteria for identifying a stream as impaired for bacterial contamination is that no more than 10% of samples taken should exceed the standard of 235 CFUs/100mL. Taking into account how streams may be listed, in order for the streams monitored during the year to pass the state's examination, none of a stream's six samples tested for *E. coli* could have exceeded the state's maximum standard. Based on the state standard, six of the ten streams examined this year would have been in violation of the bacteria standard. One of the sites, Tributary to Timsbury Creek WQ-79 violated the state bacteria standard twice (June and August). All other violations occurred only once at a given site. Tributary to Falling Creek WQ-74 had the greatest exceedence observed during the year (6700 CFUs/100mL). As a result

of this extremely high concentration of *E. coli*, a watershed investigation was initiated. A broken sewer line was identified upstream of the site and the Chesterfield County Utilities Department affected an immediate repair. After the sewer line repair, *E. coli* concentrations returned to acceptable levels below the state bacteria standard. Powhite Creek WQ-70 and Winterpock Creek WQ-71 had the two lowest annual medians, <20 CFUs/100mL and were among the four creeks that had no exceedences the state standard.

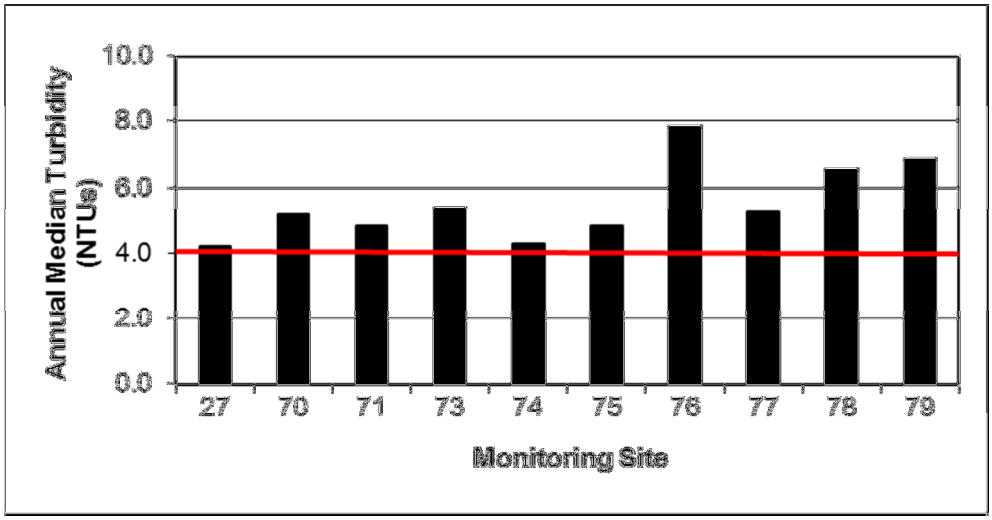

Figure 5. Annual median turbidity observations among 10 sites within Chesterfield County, 2013. The red bar represents the USEPA's local reference condition for Level III Ecoregion 45 streams (4 NTUs).

None of the streams during this monitoring year demonstrated an annual median turbidity less than or equal to the 4.0 NTUs USEPA local reference condition. Conversely, none of the streams had an annual median value that exceeded 10 NTUs (Figure 5). The greatest annual median turbidity value was observed at Tributary to Falling Creek WQ-76 (7.9 NTUs). The lowest annual median turbidity value was observed at the single creek that was noted to have high chemical water quality: Turkey Creek WQ-27 (4.2 NTUs). Overall, the turbidity measurements throughout the year indicate clear waters and suggest that the streams evaluated are not experiencing chronic elevated turbidity.

Four of the ten monitored sites are currently recorded on Virginia's impaired waters list (Table 4). Three of the four stream sites (Powhite Creek WQ-70, Winterpock Creek WQ-71 and Powhite Creek WQ-75) are impaired for not supporting aquatic life. Both Powhite Creek sites (WQ-70 and WQ-75) are also impaired for recreational contact. Tributary to Falling Creek WQ-76 is impaired for recreational contact only. The three watersheds identified as having impairments are each listed in a different impairment category. Powhite Creek (WQ-70 and WQ-75) is impaired for *E. coli* bacteria and benthic macroinvertebrates (Impaired Category 5D). Tributary to Falling Creek WQ-76 is impaired for *E. coli* bacteria alone (Impaired Category 4A). Lastly, Winterpock Creek WQ-71, is listed as naturally impaired for dissolved oxygen (Impaired Category 4C). All of the identified sites demonstrated moderate water quality. Strategies for bringing these streams into compliance with state standards will be developed by the Virginia Department of Environmental Quality.

Table 4. Monitoring sites assessed in 2013 that are currently listed as impaired state waters by the Virginia Department of Environmental Quality (VADEQ 2012).

Site Number	Stream	Virginia DEQ Status	Impairment On	Impairment Cause	Index Category
WQ-70	Powhite Creek	Impaired Category 5D	Recreation/Aquatic Life	*E. coli* bacteria & Benthic Macroinvertebrate	Moderate Quality
WQ-71	Winterpock Creek	Impaired Catergory 4C (natural)	Aquatic Life	Dissolved Oxygen	Moderate Quality
WQ-75	Powhite Creek	Impaired Category 5D	Recreation/Aquatic Life	*E. coli* bacteria & Benthic Macroinvertebrate	Moderate Quality
WQ-76	Tributary to Falling Creek	Impaired Category 4A	Recreation	*E. coli* bacteria	Moderate Quality

Conclusions:

The overall chemical water quality in the monitored streams of Chesterfield County continues to be good. The majority (9) of the streams investigated during 2013 possessed moderate or high chemical water quality. One site, Tributary to Timsbury Creek WQ-79, demonstrated low chemical water quality during 2013. The low chemical water quality score was attributed to elevated nitrate+nitrite nutrient and phosphate phosphorus concentrations and violations of the state pH and *E. coli* water quality standard. All annual medians of physical parameters were within acceptable ranges during 2013 with the exception of pH at Winterpock Creek WQ-71 and Tributary to Timsbury Creek WQ-79, where values were below the state standard. Ammonia nitrogen concentrations were at acceptable levels during 2013 with only three streams having annual median values greater than 0.04 mg/L as N. Annual median nitrate+nitrite nitrogen concentrations were generally elevated with eight of the ten monitored sites having annual median concentrations greater than 0.10 mg/L as N. Annual median concentrations of phosphate phosphorus were elevated during 2013 with eight of the ten streams demonstrating some degree of phosphate phosphorus degradation. Turbidity measurements indicated clear waters throughout the county.

In 2014 the monthly monitoring program will add ten new sites for evaluation. The new sites will be selected from based upon data from the Illicit Discharge and Detection Elimination program to assess sites that have demonstrated potential long term degradation, streams sites that are located downstream of planned development and stream sites along watershed reaches that has not been previously assessed in the monthly Watershed Assessment and Stream Protection program. Monitoring these sites throughout the year continues to provide additional information as to if these streams demonstrate impaired conditions throughout the year and/or why these sites may be impaired. The bi-monthly *E. coli* screening will continue in an effort to further establish a general baseline of expected coliform levels in county waterways throughout the year. The fluoride and potassium chemistries will still be measured on a quarterly basis for the monthly sites to continue evaluating expected groundwater quantities for both analytes.

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